PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : **A61B 5/10, 5/11, 5/113 G01P 13/00**	**A1**	**(11) International Publication Number:** **WO 91/19456** **(43) International Publication Date:** 26 December 1991 (26.12.91)

(21) International Application Number: PCT/AU91/00255

(22) International Filing Date: 14 June 1991 (14.06.91)

(30) Priority data:
PK 0641 14 June 1990 (14.06.90) AU

(71) Applicant *(for all designated States except US):* LESBAR PTY LIMITED [AU/AU]; 421 Church Street, North Parramatta, NSW 2151 (AU).

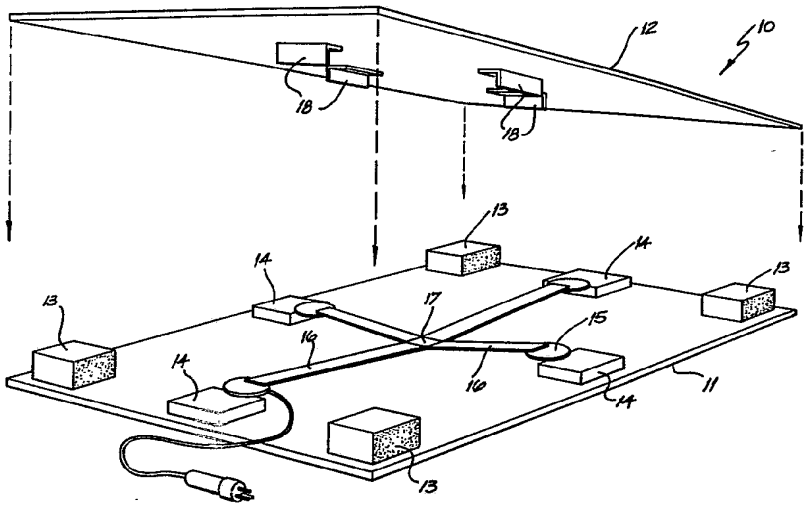
(72) Inventors; and
(75) Inventors/Applicants *(for US only) :* SPRY, John [AU/AU]; 12 Tintern Avenue, Carlingford, NSW 2118 (AU). McMahon, Newton [AU/AU]; 3 Darling Point Road, Darling Point, NSW 2027 (AU).

(74) Agent: TAYLOR, Paul, Robert; Arthur S. Cave & Co., Level 10, 10 Barrack Street, Sydney, NSW 2000 (AU).

(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
With amended claims and statement.

(54) Title: RESPIRATORY MONITOR



(57) Abstract

An apparatus (10) for monitoring respiratory movements of a person, having a lower surface member (11) and an upper surface member (12) adapted to move relative to the lower surface member (11). The upper surface member (11) is provided with at least one protrusion (18) extending downwardly therefrom which is adapted to directly or indirectly contact a piezo-electric transducer device or the like device (15), the other end of the piezo-electric device (15) being connected, also directly or indirectly, to the lower surface member (11). Preferably, each protrusion (18) contacts the piezo-electric device (15) via a flexible arm (16), for increase insensitivity of the apparatus. By sensing wether movement of the upper surface member (12) occurs an electrical signal is generated by the piezo-electric device (15) which operates an alarm in the event that respiratory movement is not sensed.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**ES**	Spain	**MG**	Madagascar
AU	Australia	**FI**	Finland	**ML**	Mali
BB	Barbados	**FR**	France	**MN**	Mongolia
BE	Belgium	**GA**	Gabon	**MR**	Mauritania
BF	Burkina Faso	**GB**	United Kingdom	**MW**	Malawi
BG	Bulgaria	**GN**	Guinea	**NL**	Netherlands
BJ	Benin	**GR**	Greece	**NO**	Norway
BR	Brazil	**HU**	Hungary	**PL**	Poland
CA	Canada	**IT**	Italy	**RO**	Romania
CF	Central African Republic	**JP**	Japan	**SD**	Sudan
CG	Congo	**KP**	Democratic People's Republic of Korea	**SE**	Sweden
CH	Switzerland			**SN**	Senegal
CI	Côte d'Ivoire	**KR**	Republic of Korea	**SU**	Soviet Union
CM	Cameroon	**LI**	Liechtenstein	**TD**	Chad
CS	Czechoslovakia	**LK**	Sri Lanka	**TG**	Togo
DE	Germany	**LU**	Luxembourg	**US**	United States of America
DK	Denmark	**MC**	Monaco		

RESPIRATORY MONITOR

The present invention relates to a respiratory monitor, and in particular to an electromechanical transducer device for monitoring respiratory movements of a person, primarily for monitoring cot-death syndrome of infants.

A number of devices are presently known for monitoring respiratory movements of persons, and in particular for monitoring cot-death syndrome of infants. Much of the development of such devices has been limited by the technology at hand, and in particular the technology as far as electrical transducer devices are concerned.

For instance, AU-B-29443/87 in the name of J.K. Frost relates to an electromechanical transducer for detecting movements of the human body. The invention discloses a device which comprises a compressible pad constructed of 'cellophane' material or the like, the device also having a microphone, such that during compression/ expansion a noise is produced by the 'cellophane', and a signal is generated therefrom. GB-A-1469488 in the name of F.A. Chandler et al discloses a granular flow sensing and switching device, wherein, the device is utilised to detect flow by means of placing a probe with a microphone in the flow and detecting an acoustic signal. The signal is then processed to give an indication as to the flow of, for instance, grains striking the probe. An electrical capacitance device is disclosed in AU-A-73917/81, wherein a plurality or sensor members are arranged one on the other such that the variation of spacing between adjacent sheets may be measured by a measure of the variation of electrical capacitance therebetween. AU-B-58956/80 in the name of E.B. Cohen discloses a movement monitoring device comprising a tubular housing with end caps and containing a freely movable ball bearing and, according to movement of the ball, an electrical signal is supplied representative of the physical activity of a person. US-A-3875929 in the name J.T. Grant utilises a microwave radar means which provides a movement sensitive field of microwave radiation. US-A-3926177 in the name of E.V. Hardway also utilises a resilient capacitive pad adapted to respond to the movement of a body by providing a capacitive

change.

It is therefore seen that, whilst the devices for monitoring respiratory movement are common, their advance is generally the improvement in the transducer means associated therewith, or, to an improvement in the arrangement of the particular transducer device.

In more recent times, for instance as disclosed in US-A-4359726 in the name of J. Lewiner et al, piezo-electric transducers are utilised. The device disclosed in the abovementioned US-A-4359726 comprises a foil interposed between two films. The foil is sensitive to pressure variations applied locally to it. AU-A-46089/85 in the name of R. Benkendorf et al also discloses the use of a piezo-electric transducer device. The construction of the Benkendorf et al device is quite complex, specifically, being a rigid base with a flexible top, between which are provided a pad. The flexible top has two rigid members, the ends being provided with a piezo-electric transducer therebetween. Upon the imposition of a force on the flexible top, which results in relative angular movement between each of the rigid members, this movement is sensed by the transducer which supplies an appropriate signal to an suitable processing circuit.

It will therefore be understood that much development has been undertaken in respect of movement detection devices, primarily associated with the advances in technology. However, despite the more recent advances, that is, the advances in respect of piezo-electric transducer devices, an efficient and sensitive device has still not yet been constructed. It will be appreciated that, particularly when the respiratory monitor is adapted to monitor cot-death syndrome, the provision of an extremely sensitive fail-safe device is imperative. Failure of a transducer to respond could well result in death of a child, and, should such a device have a low reliability by excess false triggering, an alarm signal may be prone to be ignored by an operator.

The present invention seeks to overcome the disadvantages of the prior art, by providing a highly sensitive and accurate monitoring device for the detection

of respiratory movements of a person.

In one broad form the present invention provides an electromechanical transducer device for monitoring respiratory movements of a person, said device comprising:

a lower surface member being of substantially rigid construction;

at least one support extending upwardly from said lower surface member each having a first end of a piezo-electric transducer adapted to be contacted thereby;

an upper surface member provided in spaced apart relationship from said lower surface member and adapted to move relative thereto, and having at least one protrusion extending downwardly therefrom adapted to move each protrusion adapted to move a second end of a respective piezo-electric transducer device;

such that, any substantially vertical movement sensed by said upper surface member is transferred via said protrusion to said piezo-electric transducer(s) for generation of an electrical signal.

Preferably, the electromechanical transducer device further comprises a flexible member, pivotally supported on said lower surface member and having an end portion in contact with said second end of said piezo-electric transducer, whereby an intermediate portion thereof is contacted by one of said at least one protrusion extending from said upper surface member;

such that any vertical movement of said end portion of said flexible member and said piezo-electric transducer corresponds to vertical movement of said upper surface member and said protrusion extending therefrom.

Also, preferably, the electromechanical transducer device further comprises a flexible support means constructed of foam, rubber or the like, provided at least in the corner or end portions between said upper and lower surface members, whereby vertical movement between said surface members is allowed.

In a preferred embodiment of the present invention, the electromechanical transducer device preferably has a pair of piezo-electric transducers, each at substantially end

portions of said surface members.

Also, preferably, in a preferred embodiment of the present invention the flexible member is pivotally supported in a substantially central portion thereof, with each end thereof being in contact with one of said piezo-electric transducers.

In a preferred embodiment of the invention, four piezo-electric transducer are provided, each intermediate each corner of said surface members.

In a still further preferred embodiment four piezo-electric transducers are provided, each one substantially in each corner of said surface member.

In a further broad form, the present invention provides a method of monitoring respiratory movements of a person comprising the steps of providing the electromechanical transducer device as hereinbefore described on a substantially horizontal surface, optionally providing a mattress or like apparatus thereon, and lying a person thereon to monitor said persons' respiratory movements.

The present invention will become more fully understood from the following detailed description thereof in connection with the accompanying drawing wherein:

Fig. 1 illustrates a side elevational view of an electromechanical transducer device in accordance with a preferred embodiment of the present invention;

Fig. 2 illustrates a plan view of the electromechanical transducer device as illustrated in Fig. 1.;

Fig. 3 illustrates an exploded perspective view of a four-transducer device in accordance with an alternatively preferred embodiment of the present invention;

Fig. 4 illustrates a plan view of the embodiment depicted in Fig. 3; and,

Fig. 5 illustrates an elevational view of the embodiment depicted in Fig. 3.

The electromechanical transducer device as illustrated in Figs. 1 or 2, generally designated by the numeral 1, comprises a lower surface member 2, preferably rigid in construction, and an upper surface member 3 in spaced apart relationship from the lower surface member 2, preferably

spaced apart by means of at least two flexible support members 9, at each end or in the corners of the two surface members 2 and 3. A pair of supports 4, one at each end on the lower surface member 2 are provided, and, to one side of the upper end of each support 4, is connected a piezo-electric transducer device 5. The other end of the piezo-electric transducer device 5 is adapted to be connected either directly or indirectly to the upper surface member 3, by means of a protrusion, designated 6, extending downwardly therefrom. Such protrusion 6 may either be directed immediately from the upper surface member 3 to the second end of the piezo-electric transducer device 5, or, as shown in Figs. 1 and 2, may be connected indirectly via a flexible member 7. The flexible member 7 is shown as being pivotally connected to the lower surface member 2 at a fulcrum point 8. The flexible member may be constructed of semi-rigid plastics material or the like. By providing a flexible member such as this, rather than by directly connecting the protrusion 6 from the upper surface member 3 to the second end of the piezo-electric transducer device 5, a more sensitive device is obtained. That is, should the lower tip portion of the protrusion 6 move a certain distance, then, the end portion of the flexible member 7, will move approximately twice the distance. Therefore, any minute movement on the upper surface member 3 will be transmitted and effectively amplified by means of a flexible member to the piezo-electric device 5. As with conventional piezo-electric transducing devices, an electrical current is generated with the movement of the device. Such electric current may be supplied to appropriate circuitry to activate an alarm, should lack of respiratory movement and consequential lack of movement of upper plate 3 be detected.

The electromechanical transducer device as illustrated in Figs. 3, 4 and 5, generally designated by the numeral 10, comprises a lower surface member 11, preferably rigid in construction, an upper surface member 12 in spaced apart relationship from the lower surface member 11, shown spaced apart by four compressible blocks 13, for instance, constructed of foam plastics material, in each corner,

between the two surface members 11 and 12. Intermediate the corners of the lower surface member 11, are shown four rigid transducer mounting blocks 14. Connected to one side of the upper end of each block 14 is a piezo-electric transducer device 15. The other end of the piezo-electric transducer device 15 being adapted to be connected either directly or indirectly to the upper surface member 12. In the case shown in Figs. 3, 4 and 5, flexible lever arms 16 are provided, connected at the ends thereof to the piezo-electric transducer device 15, and intermdiate their ends (forming fulcrum point) to the rigid base 11. Intermediate the fulcrum point 17 and the ends of the lever arms 16, the contacts or protrusions 18 are adapted to engage therewith. These contacts are shown connected to the upper plate 12 and extending downwardly therefrom. Obviously, alternative arrangements of connecting the upper plate 12 to the second end of the piezo-electric transducer devices 15 (either directly or indirectly) will be envisaged. It will be appreciated that the flexible lever arms 16 are preferably constructed of semi-rigid plastics material or the like. By providing flexible arms such as this rather than by directly connecting the protrusion 18 from the upper surface member 12 to the second end of the piezo-electric transducer device 15, a more sensitive apparatus is obtained. That is, should the lower tip portions of the protrusions 18 move a certain distance, then the end portions of the arms 16 will move approximately twice the distance or some proportion thereof, depending on how close to the transducer devices 15 the lever bars 18 contact the arms 16. Consequently, any minute movement of the upper surface 12 is transmitted and amplified by means of the arms 16 to the piezo-electric devices 15.

It will be understood that the present invention provides a much more sensitive respiratory monitor than the prior art devices, and in particular to the prior art associated with piezo-electric transducing devices, such as disclosed in US-A-4359726 and AU-A-46089/85.

It will however be understood that numerous variations and modifications are envisaged to the device of the present

invention, and such variations and modifications should be considered to fall within the scope of the present invention as hereinbefore described and as hereinafter claimed.

THE CLAIMS:

1. An electromechanical transducer device for monitoring respiratory movements of a person, said device comprising:

a lower surface member being of substantially rigid construction;

at least one support extending upwardly from said lower surface member each having a first end of a piezo-electric transducer adapted to be contacted thereby;

an upper surface member provided in spaced apart relationship from said lower surface member and adapted to move relative thereto, and having at least one protrusion extending downwardly therefrom adapted to move each protrusion adapted to move a second end of a respective piezo-electric transducer device;

such that, any substantially vertical movement sensed by said upper surface member is transferred via said protrusion to said piezo-electric transducer(s) for generation of an electrical signal.

2. An electromechanical transducer device as claimed in claim 1 further comprising a flexible member, pivotally supported on said lower surface member and having an end portion in contact with said second end of said piezo-electric transducer, whereby an intermediate portion thereof is contacted by one of said at least one protrusion extending from said upper surface member;

such that any vertical movement of said end portion of said flexible member and said piezo-electric transducer corresponds to vertical movement of said upper surface member and said protrusion extending therefrom.

3. An electromechanical transducer device as claimed in claims 1 or 2 further comprising a flexible support means constructed of foam, rubber or the like, provided at least in the corner or end portions between said upper and lower surface members, whereby vertical movement between said surface members is allowed.

4. An electromechanical transducer device as claimed in any one of claims 1 to 3 preferably having a pair of piezo-electric transducers, each at substantially end portions of said surface members.

5. An electromechanical transducer device as claimed in any one of claims 1 to 4 wherein said flexible member is pivotally supported in a substantially central portion thereof, with each end thereof being in contact with one of said piezo-electric transducers.

6. An electromechanical transducer device as claimed in any one of claims 1 to 5, wherein four piezo-electric transducer are provided, each intermediate each corner of said surface members.

7. An electromechanical transducer device as claimed in any one of claims 1 to 6, wherein four piezo-electric transducers are provided, each one substantially in each corner of said surface members.

8. A method of monitoring respiratory movements of a person comprising the steps of providing the electromechanical transducer device claimed in any one of claims 1 to 7 on a substantially horizontal surface, optionally providing a mattress or like apparatus thereon, and lying a person thereon to monitor said persons' respiratory movements.

9. A method of monitoring respiratory movements of a person substantially as herein described.

10. An electromechanical transducer device, substantially as herein described with reference to the accompanying drawings.

AMENDED CLAIMS

[received by the International Bureau on 29 October 1991 (29.10.91) original claims 1-10 replaced by amended claims 1-10 (2 pages)]

1. An electromechanical transducer device for monitoring respiratory movements of a person, said device comprising:

a substantially rigid lower surface member;

an upper surface member provided in spaced apart relationship from said lower surface member; and

at least one piezo-electric transducer device provided intermediate to and connected to each of said surface members;

such that, any movement sensed by said upper surface member relative to said lower surface member is transmitted and sensed by said piezo-electric transducer for generation of an electrical signal.

2. An electromechanical transducer device as claimed in claim 1, wherein said piezo-electric transducer device is connected to one or each of said surface members via projections extending transversely from one or both of said surface members.

3. An electromechanical transducer device as claimed in claim 1, wherein said piezo-electric device is connected to one or each of said surface members via a flexible member pivotally supported on one or said surface members, having an end portion in contact with one end of said piezo-electric transducer device and to the other of said surface members via a protrusion extending therefrom.

4. An electromechanical transducer device as claimed in any one of claims 1 to 3 preferably having a pair of piezo-electric transducers, each at substantially end portions of said surface members.

5. An electromechanical transducer device as claimed in claims 3 or 4 wherein said flexible member is pivotally supported in a substantially central portion thereof, with each end thereof being in contact with one of said piezo-electric transducers.

6. An electromechanical transducer device as claimed in any one of claims 1 to 5, wherein four piezo-electric transducer are provided, each intermediate each corner of said surface members.

7. An electromechanical transducer device as claimed in any one of claims 1 to 6, wherein four piezo-electric transducers are provided, each one substantially in each corner of said surface members.

8. A method of monitoring respiratory movements of a person comprising the steps of providing the electromechanical transducer device claimed in any one of claims 1 to 7 on a substantially horizontal surface, optionally providing a mattress or like apparatus thereon, and lying a person thereon to monitor said persons' respiratory movements.

9. A method of monitoring respiratory movements of a person substantially as herein described.

10. An electromechanical transducer device, substantially as herein described with reference to the accompanying drawings.

STATEMENT UNDER ARTICLE 19

1. Delete set of claims presently on file and insert new set of claims attached hereto. Claims 1, 2 and 3 have been amended for improved clarity and for distinction over the prior art documents. The remaining claims, claims 4 to 10 have only had minor alterations, if any, enacted thereto.

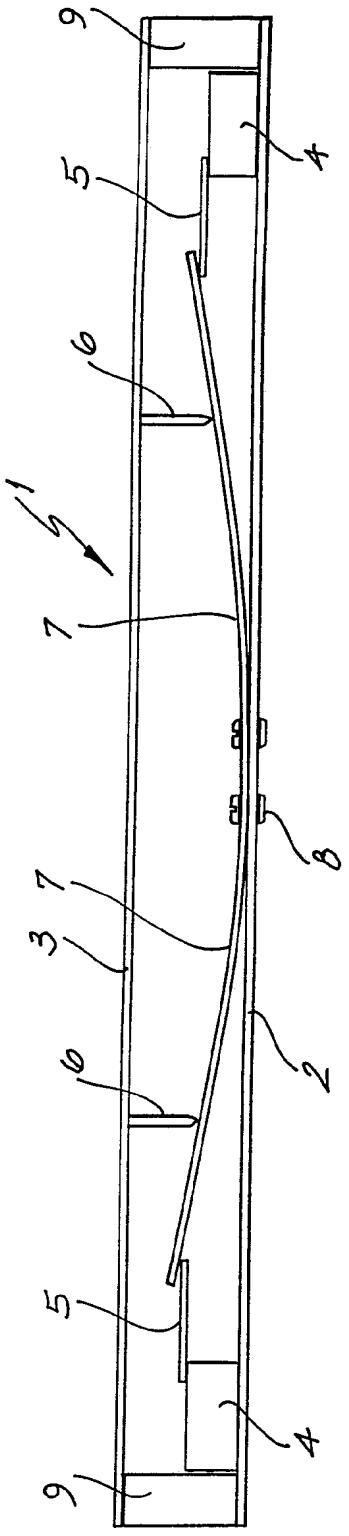


FIG. 1

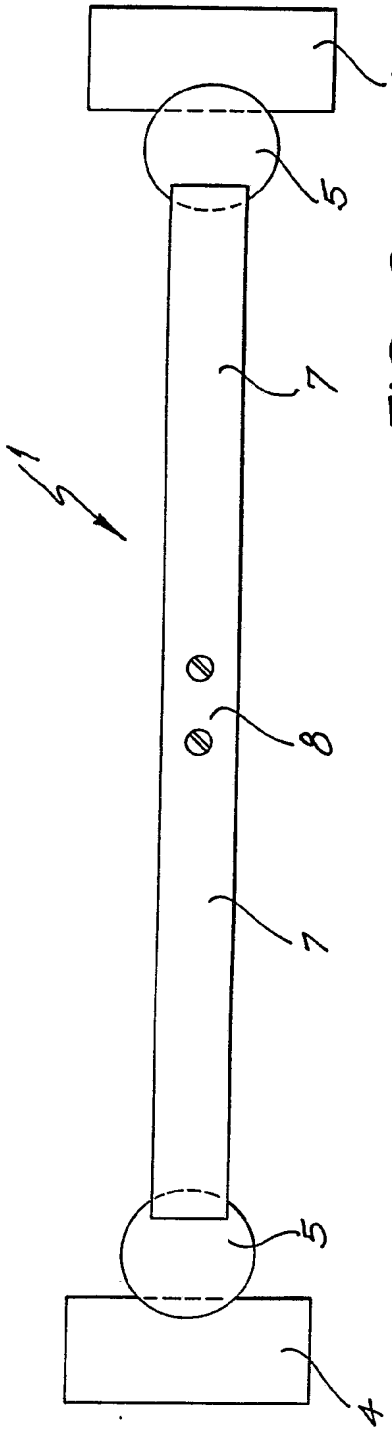


FIG. 2

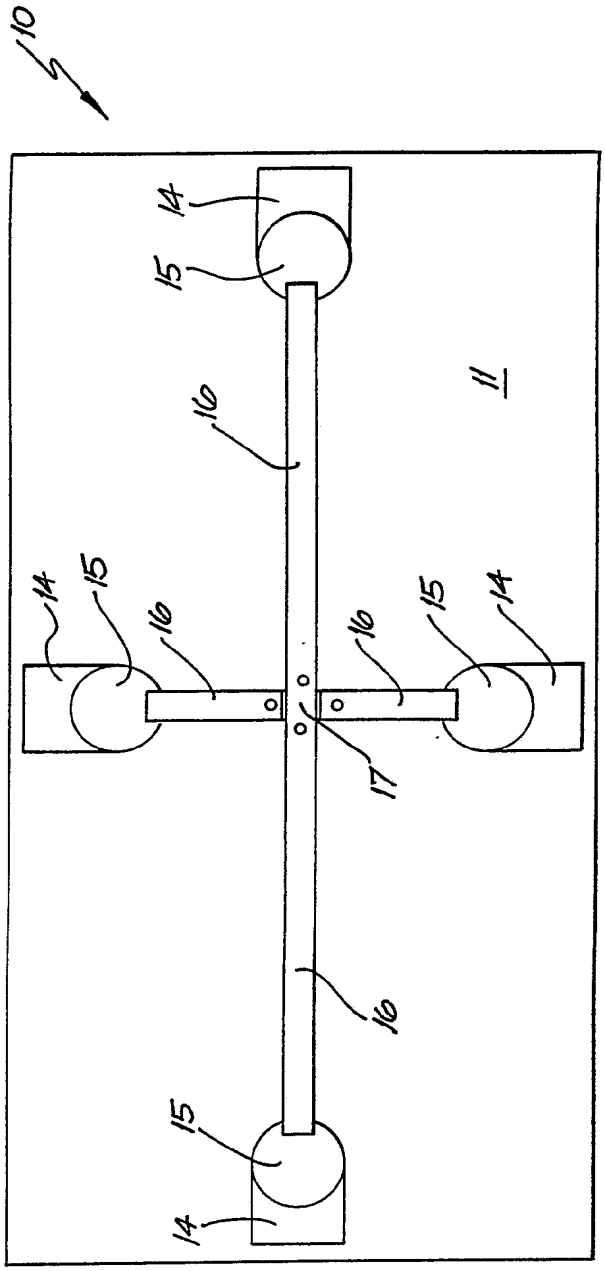


FIG. 4

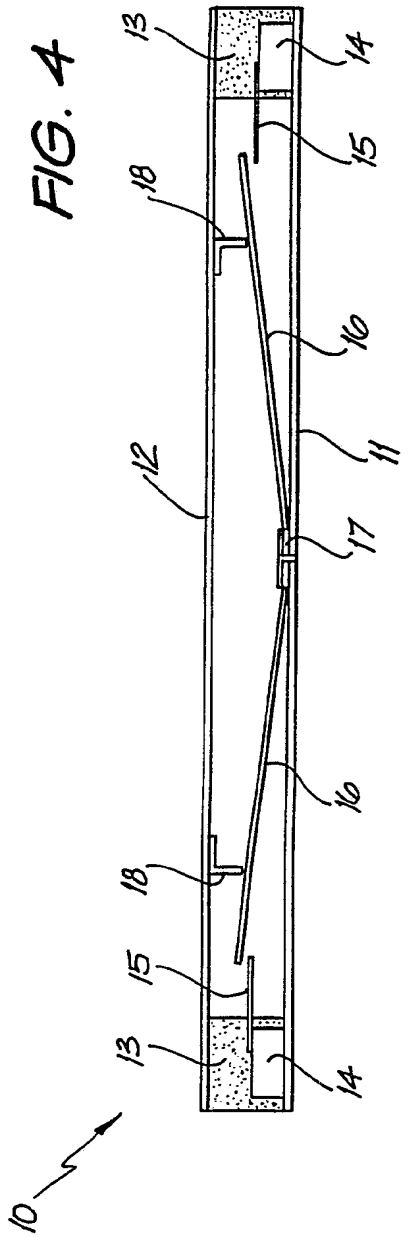


FIG. 5

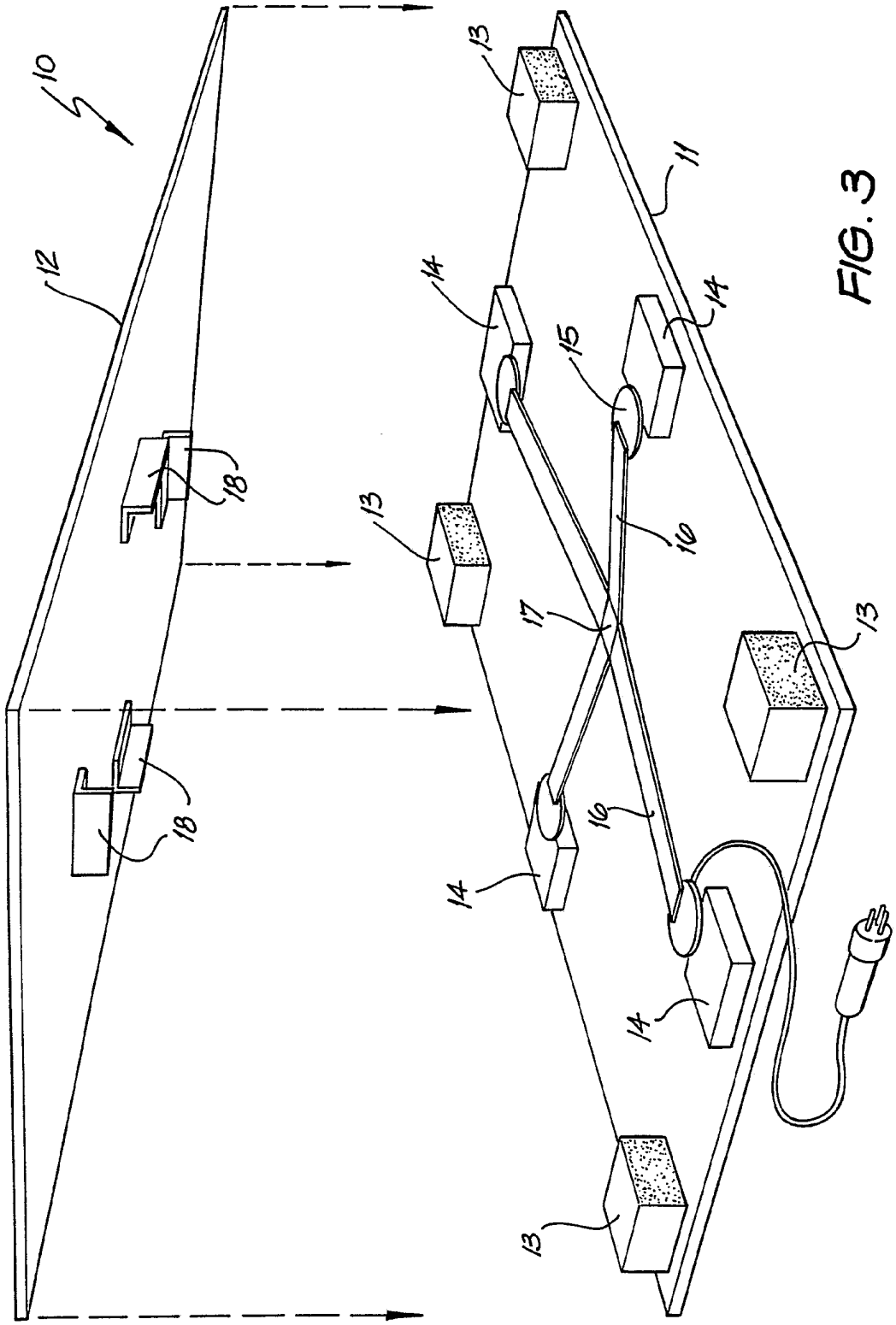


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00255

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] A61B 5/10, 5/11, 5/113 G01P 13/00

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	A61B 5/10, 5/11, 5/113 G01P 13/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	WO,A, 86/00996 (BENKENDORF) 13 February 1986 (13.02.86) Abstract, page 2, page 4 line 20 - page 6 line 20, Figs 1-2	(1-2, 8-10)
A	DE,A, 3536491 (MORGENSTERN) 16 April 1987 (16.04.87) Abstract, Claims	(1, 8)
A	DE,A, 3617012 (REENTS) 27 November 1986 (27.11.86) Abstract, Claims	(1, 8)
A	EP,A, 055345 (SIEMENS AKTIENGESELLSCHAFT) 7 July 1982 (07.07.82) Abstract, page 2 line 11 - page 3 line 13, page 4 line 27 - page 5 line 24, page 7 lines 15-34, Figs	(1, 4, 8)
A	US,A, 3926177 (HARDWAY Jr et al) 16 December 1975 (16.12.75) Whole document	(1, 8)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26 August 1991 (26.08.91)	2 September 91
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	A. HENDRICKSON

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 91/00255

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members		
DE 03536491	EP 218957 US 4884578	EP 218957	JP 62087125
DE 03617012	EP 205931		
EP 55345	DE 3049347		
US 3926177	CA 1007302 FR 2198722 JP 49065092	CA 1031829 GB 1439383 NL 7312419	DE 2345551 IT 996155 US 4033332
WO 8600996	AU 46089/85	EP 189464	

END OF ANNEX